LOI Input to SDSTA, Draft for a Ecology/Geomicrobiology Example, for internal reviews by potential participants. Please do not circulate.

Letter of Interest to the South Dakota Science and Technology Authority (SDSTA) for the Homestake Deep Underground Science and Engineering Laboratory (DUSEL)

Title: Ecology/Geomicrobiology Collaboration for Microbe Evolution

Potential Participants (to be updated during the formation of the collaboration):

Lawrence Berkeley National Laboratory, Ecology Dept., Earth Sciences Division – Terry Hazen, Gary Andersen, Eoin Brodie, Mark Conrad
South Dakota School of Mine and Technology – Sookie Band, Bruce Brierly
Joint Genome Institute – Phil Hugenholtz
Oak Ridge National Lab – Tommy Phelps
Michigan State University – Jim Tiedje
New Mexico Institute of technology – Tom Kieft
Princeton University – Tullis C. Onstott
University of Tennessee – Susan Pfiffner
Unversity of Washington – Jim Staley
University of Wisconsin – Eric Roden

Proposed Program

We at the Ecology Department, Earth Sciences Division, Lawrence Berkeley National Laboratory are interested to initiate and organize an ecology and geomicrobiology collaboration for experiments at the 4850 Laboratory and the Homestake DUSEL with a phased approach. (1) The first research focus is on the adaptation and transport of surface microbial communities to deep environments. The extensive excavations over 125 years of mining offer the unique opportunity to evaluate the evolution of underground ecology, from old mine working near the surface to recent drifts and caverns excavated at depths. (2) The second focus is on the characterization of ancient and present day, themophilic, subsurface microbial communities. A multi-institutional, multidisciplinary research team will acquire and process samples from borehole coring and from drift advancement into virgin rock formations, and from old stopes and drifts.

Space Requirement

1) extensive underground workings for sampling, (2) coordinated coring and excavation operations to preserve microorganisms, (3) drilling platform at 8000 ft level for deep coring to ~20,000 ft, 120^{o}C formations to explore the high temperature limit for life forms, (4) subsurface and surface laboratories for sample analyses, (5) Specific needs include 2 double wide anaerobic chambers (one with core access lock), -80C Freezers, Incubaters, liquid nitrogen, laminar flow hood, chemical hood, light/phase contrast microscope as a minimum (later a phase contrast microscope)

TimeLine (to be coordinated with 4850 and DUSEL Development):

2006-2007 field surveys and sample collections along the drifts during inspections
2008-2009 upper test block instrumentation, characterization, and testing; dewatering studies
2010-2012 lower block instrumentation, characterization, ecology and geomicrobiology testing
2013- couple process testing at selected blocks

Collaboration Strategy:

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We envision that the collaboration will have spokesperson(s) rotated among participants. Each organization will seek funding for specific tests and tasks individually or collaboratively from agencies and industry. The collaboration will interact with other programs or initiatives such as the SECUREarth (Scientific Energy/Environmental Cross-Cutting Underground Research to address urgent solutions to secure Earth's future) to use Homestake DUSEL facility for flow evolution, and related ecology and microbiology problems in hydrogeology, geochemistry, geophysics, rock mechanics/geoengineering, and couple processes.

Example Science Questions and Directions

Have the Cyanide-degrading bacteria that were backfilled with treated waste into the stopes survived and are they active?

Are their microbes of anthropogenic origin present in drifts of different ages? Do they provide a distinct microbial community structure signature that can be linked to mine activities and or time of abandonment?

Since the mine is so old and some drifts were abandoned more then 60 years ago prior to the use of antibiotics do anthropogenic bacteria that have survived represent an archive for unique studies, and are there pathogens and other bacteria that were only recently 'discovered' also present?

How long have microbes have been separated from surface ecosystems? And can evolutionary rates be quantified?

Is the mutational profile, inferred from sequence analyses, distinctive, reflecting expected differences in mutagenic processes?

Do the remaining genes evolve faster or more slowly than surface counterparts?

Do they exhibit genomic signatures characteristic of small population size?

Do subsurface microbes show much greater spatial structuring of populations and smaller genetic population sizes? If so, does it link to processes of genome evolution?

Are genomes reduced in size and streamlined relative to their surface counterparts?

What role do phage, lateral gene transfer and other mechanisms play in evolution?

How has genome content evolved in the absence of host and higher cell densities?

How have they adapted to different stress regimes since some are nonexistent (UV and oxidative stresses,) while energy, nutrient, radiation, dehydration are continuous?

How can macromolecules (eg. nucleic acid, lipids and proteins) remain stable for millennia?

- Evolutionary gradients, eco-genomics, and primitive life
- Fluid, energy, and organismal transport
- Impacts of human intervention on subsurface ecology

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Integration with E&O: Easy early Access to entice long term R&D interest. Immediate access to surface and near surface with soon access to moderate depths followed by stepwise access to deeper depths and deeper screened zones is ideal fro student training for decades. Will also include group trips into less utilized portions of the facility under intense safety and scrutiny.

Impact on Other Users: Builds on all early characterization efforts but does not detract or compromise any other activity. Intermittent use of individual screen zones is for hours per month. Small group recon expeditions would be hours of duration and extensively planned months prior to action under intense safety and scrutiny. Deep labs would be used of hours to weeks at a time but well planned in advance.

Readiness for Deployment of the Technology: All is ready and prepared.

Readiness of Effort and Funding: Proposals could be readied to coincide within weeks of site availability. More sophisticated workings in out years will require extensive underground facilites while some efforts can begin with mine availability.

Budget: 150k-600/y for up to 10 yrs

ES&H Issues: Fits readily within site umbrella with no major moidifications. Will require extensive safety reviews fro all underground workings. Specific ES&H will be implemented for planned excursions into loess used portions of the mine. All small group excursions into less used areas will be planned well in advance, have intense safety planning and review and will be conducted under intense safety and controls.

11/17/2005 jswang@lbl.gov